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The Resources Agency
DEPARTMENT OF FISH AND GAME

HAZARD ASSESSMENT OF THE INSECTICIDE DIMETHOATE TO AQUATIC ORGANISMS IN THE SACRAMENTO-SAN JOAQUIN RIVER SYSTEM

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PREFACE

The California Department of Fish and Game (CDFG) is responsible for protection and management of fish and wildlife. The CDFG protects fish and wildlife from pesticide hazards through consultation with the California Environmental Protection Agency's Department of Pesticide Regulation (DPR) Pesticide Registration and Evaluation Committee and Pesticide Advisory Committee. The State Water Resources Control Board and the Regional Water Quality Control Boards also protect fish and wildlife by promulgating and enforcing water quality standards for pesticides and other toxic materials. In recognition of the need for applicable environmental standards for fish and wildlife, DPR contracted with the CDFG to assess the effects of pesticides on fish and wildlife and to facilitate development of water quality criteria to protect aquatic organisms.

This document is the eighth in a series of pesticide hazard assessments. Hazard assessments have also been prepared for the herbicides molinate and thiobencarb, and for the insecticides methyl parathion, carbofuran, chlorpyrifos, diazinon, methidathion, and methomyl.

Hazard Assessment of the Insecticide Dimethoate to Aquatic Organisms in the Sacramento-San Joaquin River System

by

Stella Siepmann and Tedd Yargeau

Pesticide Investigations Unit
1701 Nimbus Road, Suite F
Rancho Cordova, California 95670

SUMMARY

Freshwater and saltwater toxicity thresholds for the protection of aquatic organisms from the insecticide dimethoate were identified, and a hazard assessment was performed for California's Sacramento-San Joaquin River system.

Forty tests on the acute and chronic toxicity of dimethoate to aquatic animals were reviewed and evaluated. The most acutely sensitive freshwater species tested was the stonefly *Pteronarcys californica* with a 96-h LC_{50} value of 43 µg/L. The most acutely sensitive saltwater species tested was the mysid *Mysidopsis bahia* with a 96-h LC_{50} value of 15,000 µg/L. The lowest freshwater Maximum Acceptable Toxicant Concentration (MATC) was 63 µg/L for cladoceran *Daphnia magna*. No chronic tests were available for marine species.

Due to the lack of study data necessary to use Environmental Protection Agency (EPA) methods in establishing Water Quality Criteria (WQC), Final Acute and Final Chronic Values could not be calculated for dimethoate. Acceptable data were available for only five of the eight freshwater and one of the eight saltwater taxa needed to derive a Final Acute Value.

Dimethoate has been detected in the Sacramento-San Joaquin River system; concentrations have been as high as 2.44 µg/L. However, approximately 75% of the 35 positive samples contained less than 0.36 µg/L dimethoate. A comparison of detected concentrations with known toxicity data indicates that dimethoate does not appear to present an acute or chronic hazard to aquatic organisms at this time. Three additional acute toxicity tests using freshwater species such as fathead minnow *Pimephales promelas*, rotifer *Philodina sp.* or *Keratella sp.*, and midge *Chironomus sp.* are required to determine freshwater water quality criteria using EPA methods. Seven additional acute toxicity tests using saltwater species such as sheepshead minnow *Cyprinodon variegatus*, mosquitofish *Gambusia affinis*, eastern oyster *Crassostrea virginica*, dungeness crab *Cancer magister*, blue crab *Callinectes spaidus*, hermit crab *Pagurus longicarpus*, and rotifer *Brachionus plicatilis* are required to determine

saltwater criteria using EPA methods. Paired acute and chronic toxicity tests should be conducted on fish and invertebrates to better define acute-to-chronic ratios.

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ACKNOWLEDGEMENTS

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INTRODUCTION

The organophosphate insecticide and acaricide dimethoate is used on alfalfa, vegetables, citrus fruit, cotton, grapes, and other crops. From 1989 to 1993, the amount of dimethoate used in California ranged from 529,143 to 1,218,762 lbs per year (Table 1) (Department of Pesticide Regulation 1989-93).

The Central Valley Regional Water Quality Control Board (CVRWQCB), California Department of Pesticide Regulation (DPR), and U.S. Geological Survey (USGS) monitored dimethoate from March 1991 to February 1993 in the San Joaquin River system (Table 2). Detected concentrations of dimethoate ranged from 0.05 to 2.44 µg/L. However, approximately 75% of the 35 positive samples contained less than 0.36 µg/L dimethoate. DPR monitored dimethoate in the Sacramento River system from November 1993 to November 1994. No dimethoate was detected during the sampling period.

Hazards from dimethoate to aquatic life in the Sacramento-San Joaquin River system were assessed by comparing expected toxic effects with dimethoate concentrations detected in the Sacramento-San Joaquin River drainage. The toxic effects of dimethoate were assessed by evaluating toxicity tests for conformance with specific criteria adapted from the U.S. Environmental Protection Agency (EPA) and the American Society for Testing of Materials (ASTM). Although toxicity tests were not required to comply with all criteria, tests were rejected if they did not observe certain fundamental procedures, such as maintaining sufficient organism survival in control treatments. The California Department of Fish and Game's (CDFG) assessments are based on data from accepted tests and procedures adapted from EPA (1985) guidelines (Appendix A). Neither the U.S. EPA nor the National Academy of Sciences (NAS) have established a Water Quality Criteria (WQC) for dimethoate. The California Department

of Health Services has set an action level of 140 mg/L for dimethoate in drinking water.

Table 1. Dimethoate use in California 1989-93[a]

Year	Pounds used
1989	529,143
1990	880,402
1991	1,218,762
1992	669,691
1993	611,387

[a]California Department of Pesticide Regulation Pesticide Use Reports 1989-1993

Table 2. Concentrations of dimethoate (μg/L) detected in the San Joaquin River system (SJR), March 1991 through February 1993.[a]

Date	Location[b]	Concentration
4/15/91	Newman Wasteway	2.13
4/16/91	Newman Wasteway	2.13
7/28/92	Newman Wasteway	0.23
8/25/92	Newman Wasteway	0.88
7/15/92	SJR at Patterson	0.05
7/29/92	SJR at Patterson	0.06
8/5/92	SJR at Patterson	0.06
8/19/92	SJR at Patterson	0.05
8/26/92	SJR at Patterson	0.07
9/2/92	SJR at Patterson	0.09
9/9/92	SJR at Patterson	0.05
7/15/92	SJR at Laird Park	0.06
7/22/92	SJR at Laird Park	0.10
7/30/92	SJR at Laird Park	0.22
8/5/92	SJR at Laird Park	0.14
8/12/92	SJR at Laird Park	0.14
8/19/92	SJR at Laird Park	0.07
8/27/92	SJR at Laird Park	0.07
9/2/92	SJR at Laird Park	0.11
9/9/92	SJR at Laird Park	0.19
7/31/92	SJR at Maze Blvd.	0.18
8/28/92	SJR at Maze Blvd.	0.10
8/5/92	SJR at Hills Ferry	0.19
8/19/92	SJR at Hills Ferry	2.44
8/25/92	SJR at Hills Ferry	0.06
9/2/92	SJR at Hills Ferry	0.80
9/9/92	SJR at Hills Ferry	0.19
7/31/92	SJR at Vernalis	0.10
8/28/92	SJR at Vernalis	0.06
4/16/91	Ingraham/Hospital Creeks	0.18
7/31/92	Ingraham/Hospital Creeks	0.34
8/28/92	Ingraham/Hospital Creeks	0.36
7/9/92	Orestimba Creek	0.58
8/26/92	Orestimba Creek	0.61
7/29/92	Del Puerto Creek	0.94

[a]Unpublished data from the Department of Pesticide Regulation

[b]These and other locations were sampled in 1991, 1992, and 1993. Only the dates on which dimethoate was detected are listed.

ENVIRONMENTAL FATE

Dimethoate is an organophosphate insecticide and acaricide. Hydrolysis $t_{1/2}$ is 68 days (DPR 1994). The water solubility of dimethoate is 39,800 mg/L at 25°C (DPR 1994). Dimethoate soil adsorption is relatively low, with an average soil adsorption coefficient (K_{oc}) of 11 cm^3/g (DPR 1994). The aerobic metabolism of dimethoate is 2 days and the anaerobic metabolism is 22 days (DPR 1994).

The moderate water solubility and low K_{oc} of dimethoate indicate that the chemical has the potential to be carried in field runoff water or to leach to groundwater (Johnson 1991). However, dimethoate hydrolysis and soil half-life vary, and the tendency of dimethoate to run off or leach would depend on field conditions.

TOXICITY TO AQUATIC ORGANISMS

Acute Toxicity to Aquatic Animals

Thirty-four tests on the acute toxicity of dimethoate to aquatic animals were evaluated (Appendix B). Six of these tests were accepted (Table B-1) and twenty-eight were not accepted (Table B-2).

EPA (1985) guidelines recommend eight families of freshwater organisms for which acceptable data should be available for deriving a freshwater Final Acute Value (FAV) (Table 3). Acceptable data were available for five of the recommended eight freshwater families. Suggested organisms are given to complete the eight families recommended by the EPA (Table 3). Of the eight recommended families for calculation of a saltwater WQC, toxicity data were available for only one family. Organisms suggested to complete the eight families are given (Table 4).

Genus Mean Acute Values (GMAVs) were calculated using data from accepted acute toxicity tests and were ranked in ascending order (Table 5). The freshwater GMAVs ranged from 43 µg/L, the 96-h LC_{50} value for the stonefly *Pteronarcys californica*, to 8,560 µg/L, the 96-h LC_{50} value for the rainbow trout *Oncorhynchus mykiss*.

Usually, the four lowest GMAVs are the most significant determinants of the FAV. For dimethoate, the lowest four GMAVs for freshwater organisms were for the stonefly *Pteronarcys californica*, amphipod *Gammarus lacustis*, cladoceran *Daphnia magna*, and the bluegill *Lepomis macrochirus*. However, due to lack of sufficient data from all eight categories of freshwater organisms, a freshwater FAV was not calculated.

Acceptable data were available for only one saltwater species, mysid *Mysidopsis bahia*, so a saltwater FAV could not be calculated. The mean 96-h LC_{50} value for *M. bahia* was 15,000 µg/L.

Table 3. Eight families of freshwater aquatic animals recommended by EPA (1985) for use in deriving the freshwater FAV and representative species for which dimethoate acute toxicity data were available, and suggested species to provide the necessary data.

Family	Available Species	Suggested Species
1. One Salmonid	Rainbow trout	N/A[a]
2. Another family in class Osteichthyes	Bluegill	N/A
3. Another family in phylum Chordata	None	Fathead minnow
4. One family not in phylum Arthropoda or Chordata	None	Rotifer
5. One insect family or any phylum not already represented	None	Midge
6. One planktonic crustacean	Cladoceran	N/A
7. One benthic crustacean	Amphipod	N/A
8. One insect	Stonefly	N/A

[a]Not applicable. Acceptable data available for category.

Table 4. Eight families of saltwater aquatic animals recommended by EPA (1985) for use in deriving the saltwater FAV and representative species for which dimethoate acute toxicity data were available, and suggested species to provide the necessary data.

Family	Available Species	Suggested Species
1, 2. Two families in phylum Chordata	None	Sheepshead minnow Mosquitofish
3. One family not in phylum Arthropoda or Chordata	None	Eastern oyster
4, 5, 6. Three other families not in phylum Chordata	None	Dungeness crab, blue crab, hermit crab
7. A mysid or penaeid	Mysid	N/A[a]
8. One other family not already represented	None	Rotifer

[a]Not applicable. Acceptable data available for category.

Table 5. Ranked Genus Mean Acute Values (GMAV) from accepted acute toxicity tests on freshwater species used to calculate the freshwater FAV.

Rank	GMAV (µg/L)	Species
1	43	Stonefly *Pteronarcys californica*
2	200	Amphipod *Gammarus lacustis*
3	1,844[a]	Cladoceran *Daphnia magna*
4	6,000	Bluegill *Lepomis macrochirus*
5	8,560	Rainbow trout *Oncorhynchus mykiss*

[a]GMAV based on geometric mean of more than one LC_{50} for this species.

Chronic Toxicity to Aquatic Animals

Six tests on the chronic toxicity of dimethoate were evaluated (Appendix C). Two of these tests were accepted (Table C-1); four were not accepted (Table C-2). The lowest Maximum Acceptable Toxicant Concentration value (MATC) was 63 µg/L for cladoceran *Daphnia magna* (Table C-1).

The EPA (1985) guidelines specify calculating the Acute-Chronic Ratio (ACR) for a species using for the numerator the geometric mean of LC_{50} values and for the denominator the geometric mean of MATC values. Freshwater or saltwater Final ACR values are derived using ACR values of both freshwater and saltwater species, including at least a fish, an invertebrate, and an acutely sensitive species. The FACR value used to derive a freshwater Final Chronic Value (FCV) should include an acutely sensitive freshwater species. The other species used may be either freshwater or saltwater.

However, insufficient data were available to follow EPA (1985) guidelines for deriving the FACR value. Even if a FACR

value was calculated, its utility would be limited as there were no FAVs for calculating FCVs. Because of the lack of data, FCVs were not calculated.

Toxicity to Aquatic Plants

Thirty-nine tests on the toxicity of dimethoate to aquatic plants were evaluated (Appendix D) to derive a Final Plant Value (FPV). The FPV is the lowest concentration of pesticide that demonstrates a biologically important toxic endpoint (EPA 1985). In tests for which specific values were reported, the lowest concentration at which growth was inhibited was 1,000 µg/L for cyanobacteria *Chlorella vulgaris*, and the FPV for dimethoate is 1,000 µg/L. None of the tests indicated that dimethoate was more toxic to aquatic plants than to aquatic animals, therefore criteria that protect aquatic animals will also protect aquatic plants.

HAZARD ASSESSMENT

Water Quality Criterion

The EPA guidelines specify that a WQC consists of two concentrations, the Criterion Maximum Concentration (CMC) to protect against acute toxicity and the Criterion Continuous Concentration (CCC) to protect against chronic toxicity. The CMC is equal to one-half the FAV. The CCC is equal to the lowest of three values: the FCV, the FPV, or the Final Residue Value (Appendix A).

Because of the lack of data for dimethoate, EPA (1985) methods for establishing WQC cannot be followed.

Hazard to Aquatic Animals

Although dimethoate has been detected in the San Joaquin River system at concentrations as high as 2.44 µg/L, approximately 75% of the 35 positive samples contained less than 0.36 µg/L dimethoate. Monitoring data suggest that dimethoate may be a chronic contaminant in the Sacramento-San Joaquin drainage (Table 2). A comparison of detected concentrations with known toxicity data indicates that dimethoate does not appear to present an acute or chronic hazard to aquatic organisms at this time. It appears that the toxicity of some insecticides commonly found together in the Sacramento-San Joaquin drainage is additive (CDFG 1992). Calculation of WQC may need to take into account additive effects of pesticides likely to be present concurrently in the Sacramento-San Joaquin drainage. Monitoring data for saltwater are not available, but dimethoate concentrations are likely to be lower than in freshwater.

Data Requirements

Acute toxicity data were available for five of the eight freshwater families recommended by the EPA (1985) (Table 3). Three additional acute toxicity tests using freshwater species such as fathead minnow *Pimephales promelas*, rotifer *Philodina sp.* or *Keratella sp.*, and midge *Chironomus sp.* are required to determine freshwater water quality criteria using EPA methods. Acute toxicity data were available for one of the eight saltwater families recommended by the EPA (1985) (Table 4). Seven additional acute toxicity tests using saltwater species such as sheepshead minnow *Cyprinodon variegatus*, mosquitofish *Gambusia affinis*, eastern oyster *Crassostrea virginica*, dungeness crab *Cancer magister*, blue crab *Callinectes spaidus*, hermit crab *Pagurus longicarpus*, and rotifer *Brachionus plicatilis* are required to determine saltwater criteria using EPA methods. Acceptable chronic toxicity data were available for only one fish and one invertebrate. Paired acute and chronic toxicity tests should be conducted on fish and invertebrates to better define acute-to-chronic ratios.

Monitoring of the Sacramento-San Joaquin River system should be continued to help assess hazards posed by dimethoate to aquatic species. Once additional studies become available the CDFG may reassess the hazards posed by dimethoate to aquatic species.

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APPENDIX A. Procedures used by the California Department of Fish and Game to prepare hazard assessments.

The California Department of Fish and Game (CDFG) Pesticide Investigations Unit assesses the hazard of pesticides to aquatic organisms. The hazard assessment procedure includes evaluation of toxicity studies, establishment of the Water Quality Criterion (WQC), and assessment of potential hazards.

Acute and chronic toxicity data are obtained from studies published in scientific literature and laboratory reports required by the U. S. Environmental Protection Agency for pesticide registration. The CDFG evaluates the quality of these data by evaluating the tests for compliance with standards adapted from the EPA and the American Society for Testing and Materials (ASTM). The tests are evaluated for compliance with standards for test type, method, design and species, and for water quality and toxicant monitoring and maintenance. Although a study need not comply with every standard, tests are rejected if they do not observe certain fundamental procedures or if several important standards are not met. Studies are also rejected if they do not contain sufficient information to be properly evaluated and the necessary information cannot be obtained from the original researcher.

Acute toxicity data from acceptable tests on freshwater and saltwater organisms are used to determine a Final Acute Value (FAV). The EPA (1985) guidelines recommend eight categories of freshwater organisms for which data should be available for deriving a freshwater FAV, and eight categories of saltwater organisms for deriving a saltwater FAV.

The FAV is calculated as follows:

1. The Species Mean Acute Value (SMAV) is the geometric mean of EC_{50} values and LC_{50} values from all accepted toxicity tests performed on that species.

2. The Genus Mean Acute Value (GMAV) is the geometric mean of all SMAVs for each genus.

3. The GMAVs are ranked (R) from "1" for the lowest to "N" for the highest. Identical GMAVs are arbitrarily assigned successive ranks.

4. The cumulative probability (P) is calculated for each GMAV as $R/(N+1)$.

5. The four GMAVs with cumulative probabilities closest to 0.05 are selected. If fewer than 59 GMAVs are available, these will always be the four lowest GMAVs.

6. The FAV is calculated using the selected GMAVs and Ps, as follows:

$$S^2 = \frac{\Sigma((\ln GMAV)^2) - ((\Sigma(\ln GMAV))^2/4)}{\Sigma(P) - ((\Sigma(\sqrt{P}))^2/4)}$$

$$L = (\Sigma(\ln GMAV) - S(\Sigma(\sqrt{P})))/4$$

$$A = S(\sqrt{0.05}) + L$$

$$FAV = e^A$$

Chronic toxicity data from acceptable tests on freshwater and saltwater organisms are used to determine a Final Chronic Value (FCV). If data are available for the eight families, the FCV is calculated using the same procedure as described for the FAV. If sufficient data are not available, the following procedure is used:

1. Chronic values are obtained by calculating the geometric mean of the NOEC and the LOEC values from accepted chronic toxicity tests.

2. Acute-Chronic Ratios (ACR) are calculated for each chronic value for which at least one corresponding acute value is

available. Whenever possible, the acute test(s) should be part of the same study as the chronic test.

3. The Final ACR (FACR) is calculated as the geometric mean of all the species mean ACRs available for both freshwater and saltwater species.

4. FCV = FAV/FACR.

Plant toxicity data from algae or aquatic vascular plants are used to determine a Final Plant Value (FPV). The FPV is the lowest result from a test with a biologically important endpoint.

The EPA guidelines specify that a WQC consists of two concentrations, the Criterion Maximum Concentration (CMC), and the Criterion Continuous Concentration (CCC). The CMC is equal to one-half the FAV. The CCC is equal to the lowest of three values: the FCV, the FPV, or the Final Residue Value (FRV). The FRV is intended to prevent pesticide concentrations in recreational or commercially important species from affecting marketability because of excedence of applicable action levels, and to protect wildlife that consume aquatic organisms. The WQC can be lowered to protect important resident species (EPA 1985).

The WQC is stated as follows: (Freshwater/saltwater) aquatic organisms should not be affected unacceptably if the four-day average concentration of (pesticide) does not exceed (CCC value), and if the one-hour average concentration does not exceed (CMC value) more than once every three years on the average.

Hazard assessment is an iterative process by which new data are evaluated to refine the WQC. Hazard assessments frequently recommend additional toxicity tests with sensitive native species and commonly-used test organisms listed by ASTM.

APPENDIX B. Abstracts of accepted and unaccepted acute toxicity tests reviewed for hazard assessment.

Accepted acute toxicity tests - The following tests used accepted test methods.

Beusen and Neven (1989) - In 1989, 48-h static toxicity tests were performed by Studiecentrum voor Ecologie en Bosbouw on dimethoate (99%) with <24-h old cladocerans *Daphnia magna*. The Commission of European Communities (1984) testing standards were used. Five concentrations were tested and a control was used. Tests were conducted using either an open system or a closed (stoppered) system. Four (open) and two (closed) replicates per concentration were tested. Exposure levels were measured during the test and measured concentrations averaged >90% of nominal concentrations. Water quality parameters during the test were: temperature of 19±1°C; pH of 8.2 to 8.4; dissolved oxygen above 6 mg/L; and hardness of 223 mg/L. Control survival was 100%. The LC_{50} values for *D. magna* were 1,700 µg/L (open) and 2,000 µg/L (closed).

Graves and Swigert (1993a) - In 1993, a 96-h static toxicity test was performed by Wildlife International Laboratories in Easton, Maryland on dimethoate (99%) with juvenile mysids *Mysidopsis bahia*. ASTM (1988) test standards were used. Six concentrations were tested in replicate and a water control was used. Concentrations were measured at the beginning and end of the test. Water quality parameters were: temperature of 24.1 to 25.2°C; pH of 8.4; dissolved oxygen of <60% saturation; and salinity of 21 °/$_{oo}$. Control survival was 100%. The LC_{50} for *M. bahia* was 15,000 µg/L.

Mayer and Ellersieck (1986) - In 1964, 96-h static toxicity tests were performed by the Fish Pesticide Research Laboratory on dimethoate (percent active ingredient not given) with second year class stoneflies *Pteronarcys californica*. No commonly recognized

testing standards were used. Three concentrations of dimethoate were tested and a control was used. Ten replicates per concentration were tested. Water quality parameters during the test were: temperature of 60°F; pH of 7.1; and hardness of 44 mg/L. The LC_{50} for stonefly was 43 µg/L.

Mayer and Ellersieck (1986) - In 1964, 96-h static toxicity tests were performed by the Fish Pesticide Research Laboratory on dimethoate (percent active ingredient not given) with bluegill *Lepomis macrochirus*. Testing standards similar to EPA (1975) were used. Six concentrations were tested and a control was used. Ten replicates per concentration were tested. Water quality parameters during the test were: temperature of 75°F; pH of 7.4; and hardness of 44 mg/L. Control survival was 100%. The LC_{50} for bluegill was 6,000 µg/L.

Mayer and Ellersieck (1986) - In 1965, 96-h static toxicity tests were performed by the Fish Pesticide Research Laboratory on dimethoate (97.4%) with mature amphipods *Gammarus lacustis*. Test standards similar to EPA (1975) were used. Five concentrations of dimethoate were tested and a control was used. Ten replicates per concentration were tested. Water quality parameters during the test were: temperature of 70°F; pH of 7.1; and hardness of 44 ppm. Control survival was 100%. The LC_{50} for *G.lacustis* was 200 µg/L.

Mayer and Ellersieck (1986) - In 1968, static toxicity tests were performed by the Fish Pesticide Research Laboratory on dimethoate (100%) with rainbow trout *Oncorhynchus mykiss*. Test standards similar to EPA (1975) were used. Eight concentrations were tested and a control was used. Ten replicates per concentration were tested. Water quality parameters during the test were: temperature of 13°C; pH of 7.7; and hardness of 13.5 mg/L. Control survival was 100%. The LC_{50} for rainbow trout was 8,560 µg/L.

Unaccepted acute toxicity tests - The following tests did not use accepted test methods and/or produce accepted results.

Basak and Konar (1978) - In 1978, a 168-h toxicity tests were performed by the Fisheries Laboratory, Department of Zoology, Kalyani University, on dimethoate (30%) with carp *Cyprinus carpio*, singhi *Heteropneustes fossilis* and tilapia *Tilapia mossambica*. APHA (1971) testing standards were used. Water quality parameters during the test were: temperature of 20 to 24°C; pH of 7; and dissolved oxygen of 7.3 mg/L. The LC_{50} values for carp, singhi, and tilapia were 22,390, 45,710, and 23,770 µg/L, respectively. These values were not used because the percent active ingredient in the formulated product was below 90% and essential information such as control survival was not given.

Beusen and Neven (1989) - In 1989, 48, 96 and 168-h static toxicity tests were performed by Studiecentrum voor Ecologie en Bosbouw on dimethoate (10%) with <24-h old cladoceran *Daphnia magna*, guppy *Poecilia reticulata* and zebrafish *Brachydanio rerio*. The Commission of European Communities (1984) testing standards were used. Four (open) and two (closed), three or two replicates per concentration were tested. Exposure levels were measured at 1 to 7 mg/L during the test and measured concentrations averaged 10% of nominal concentrations. Water quality parameters during the test were: temperatures of 19.5±1°C (cladoceran) and 23±2°C (guppy); pH of 8.2 to 8.4 (cladoceran) and 7.4 to 8.4 (guppy); dissolved oxygen of >6 mg/L; and hardness of 223 mg/L. Control survival was 100%. The LC_{50} values ranged from 830 to 1,600 µg/L for *D. magna*, from 10,400 to 15,700 µg/L for guppy, and from 6,200 to 8,200 µg/L for zebrafish. These values were not used because the percent active ingredient in the formulated product was below 90%.

Graves and Swigert (1993b) - In 1993, a 96-h flow through toxicity test was performed by Wildlife International

Laboratories in Easton, Maryland on dimethoate (99%) with eastern oyster *Crassostrea virginica* (life stage not given). ASTM (1988) test standards were used. Five concentrations were tested in replicate and solvent and water controls were used. Concentrations were measured at the beginning and end of the test and measured concentrations were 103 to 110% of nominal concentrations. Water quality parameters during the test were: temperature of 21.6 to 22.2°C; pH of 8.1 to 8.2; dissolved oxygen of >60% saturation; and salinity of 18-20 °/$_{oo}$. Control survival was 100%. The EC_{50} for eastern oyster was 113,000 µg/L. This value was not used because the mortality range was unacceptable.

Graves and Swigert (1993c) - In 1993, a static toxicity test was performed by Wildlife International Laboratories in Easton, Maryland on dimethoate (99%) with juvenile sheepshead minnow *Cyprinodon vareigatus*. ASTM (1988) test standards were used. Six concentrations were tested in replicate and a water control was used. Concentrations were measured at the beginning and end of the test. Water quality parameters were: temperature of 21.7 to 22.3°C; pH of 8.4; dissolved oxygen of >60% saturation; and salinity of 21 °/$_{oo}$. Control survival was 100%. The LC_{50} value for sheepshead minnow was >111,000 µg/L. This value was not accepted because the mortality range was unacceptable.

Kulshrestha et al. (1986) - In 1986, 96-h static toxicity tests were performed by the Government Motilal Science College, India, on dimethoate (30%) fingerling carps *Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*. No commonly recognized test standards were mentioned. The number of concentrations tested was not given. A control was used. Concentrations were not measured. Water quality parameters were: temperature of 25 to 29°C; dissolved oxygen of 8 to 8.4 mg/L; pH of 7.2; and hardness of 60 to 70 mg/L. Control survival was 90%. The 96-h LC_{50} value was 10,500 µg/L for *Catla catla*, 10,200 µg/L for *Labeo rohita*, and 10,100 µg/L for *Cirrhinus mrigala*. These values were not used

because the percent active ingredient in the formulated product was below 90%.

Mayer and Ellersieck (1986) - In 1965, 96-h static toxicity tests were performed by the Fish Pesticide Research Laboratory on 100% dimethoate with rainbow trout *Oncorhynchus mykiss*. Testing standards similar to EPA (1975) were used. Eight concentrations were tested and a control was used. Water quality parameters during the test were: temperature of 55°F; pH of 7.1; and hardness of 44 mg/L. Control survival was 100%. The LC_{50} value was 6,200 µg/L. This value was not used because dissolved oxygen was not measured and the mortality range was unacceptable. For a valid LC_{50} value, one treatment other than the control must kill <37% of the test organisms and one treatment must kill >63% of the test organisms.

Rettich (1979) - In 1979, a 48-h acute toxicity test was performed by the Institute of Hygiene and Epidemiology in Prague, Czechoslovakia on dimethoate (5%) with fourth instar mosquitos *Culex pipiens* molestus. No commonly recognized test standards were used. Five concentrations were tested in replicate and a water control was used. Concentrations were not measured. Water temperature was 20 to 22°C. Other water quality parameters were not given. Control survival was ≥80%. The LC_{100} was 500 µg/L. This value was not used because the percent active ingredient in the formulated product was below 90%.

Roales and Perlmutter (1974) - In 1974, a 72-h toxicity test was performed by New York University on dimethoate (99%) with embryo zebrafish *Brachydanio rerio*. No commonly recognized test standards were used. Five concentrations were tested and a water control was used. Concentrations were not measured. The dissolved oxygen level was >6 mg/L throughout the test. No other water quality parameters were given. Control survival was not given. The 72-h TL_m (Median tolerance limit is the concentration

of material in water at which 50% of the test organisms survive after a specified time of exposure; The TLm has been replaced by the LC_{50}) was 259,000 µg/L. This value was not used because the test duration was too short.

Schmidt et al. (1961) - In 1961, a 24-h toxicity test was performed by Entomology Research Division, USDA, on dimethoate (percent active ingredient not given) with fourth instar mosquitos *Anopheles quadrimaculatus*, *Aedes aegypti*, and *Aedes taeniorhynchus*. No commonly recognized test standards were mentioned. Ten concentrations were tested. No controls were mentioned. Concentrations were not measured. Water quality parameters were not given. Effects were not given. This test was not accepted because an LC_{50} was not determined, and essential information, such as control survival, was not given.

Shafiei and Costa (1990) - In 1988, a 48-h static toxicity test was performed by the University of Kelaniya, Sri Lanka on Rogor-40 with fry and fingerling freshwater fish *Oreochromis mossambicus* Peters. No commonly recognized test standards were mentioned. The number of concentrations tested was not given. Three replicates and a control were used. Concentrations were not measured. Water temperature was 28 to 29°C. Other water quality parameters were not given. The LC_{50} for fry was 28,510 µg/L and for fingerlings was 31,260 µg/L. These values were not used because the percent active ingredient in the formulated product was below 90%.

Toor et al. (1973) - In 1972, a 72-h static toxicity test was performed by Punjab Agricultural University, Ludhiana on dimethoate (40%) with carp *Cyrpinus carpio* commmunis. No commonly recognized test standards were mentioned. Two concentrations were tested. No control was mentioned. Concentrations were not measured. Water temperature was 25°C. No other water quality parameters were given. Effects were not

given. This test was not accepted because an LC_{50} was not determined, the percent active ingredient in the formulated product was below 90%, and an inadequate number of concentrations were tested.

Verma et al. (1982) - In 1982, a 96-h static toxicity test was performed by D.A.V. College, India on dimethoate (30%) with cyprinid *Saccobranchus fossilis* (life stage not given). APHA (1971) testing standards were used. The number of concentrations tested was not given. Each concentration was tested in replicate and a solvent control was used. Water quality parameters were: temperature of 16.2 to 20.2°C; dissolved oxygen of 4.84 mg/L; and pH of 7 to 7.4. Control survival was 100%. The 96-h LC_{50} for *S. fossilis* was 4,570 µg/L. This value was not used because the percent active ingredient in the formulated product was below 90%.

B-1. Values (µg/L) from accepted tests on the acute toxicity of dimethoate to aquatic animals.

Species	Life Stage	Method[b]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (95% C.L.[c])	Reference
Amphipod *Gammarus lacustis*	mature	S,M	Technical (97.4%)	44 mg/L	96-h	LC_{50}	200 (150-270)	Mayer and Ellersieck 1965
Bluegill *Lepomis macrochirus*	N/A[a]	S,M	Technical (N/A)	44 mg/L	96-h	LC_{50}	6,000 (N/A)	Mayer and Ellersieck 1964
Cladoceran *Daphnia magna*	<24-h	S,M	Technical (99%)	223 mg/L	48-h	LC_{50}	1,700 (1,500-2,000)	Beusen and Neven 1989
Mysid *Mysidopis bahia*	juv.	S,M	Technical (99%)	21 °/oo	96-h	LC_{50}	15,000 (13,000-18,000)	Graves and Swigert 1993a
Rainbow trout *Oncorhynchus mykiss*	N/A	S,U	Technical (100%)	13.5 mg/L	96-h	LC_{50}	8,560 (5,300-13,800)	Mayer and Ellersieck 1968
Stonefly *Pteronarcys californica*	2nd yr.	S,U	Technical (N/A)	44 mg/L	96-h	LC_{50}	43 (36-51)	Mayer and Ellersieck 1964

[a] N/A = Not available

[b] S = Static F = Flow through M = Measured concentrations U = Unmeasured concentrations

[c] Confidence limits

Table B-2. Values (μg/L) from unaccepted tests on the acute toxicity of dimethoate to aquatic animals.

Species	Life Stage	Method[b]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (95% C.L.[c])	Reference	Test Deficiencies[d]
Carp *Cyprinus carpio*	N/A	S,U	Formulation (30%)	N/A	168-h	LC_{50}	22,390 (N/A)	Basak and Konar 1978	1,2
Carp *Cyprinus carpio*	N/A	S,U	Formulation (40%)	N/A	72-h	N/A		Toor et al. 1973	1,3,4
Carp *Catla catla*	finger-ling	S,U	Formulation (30%)	60-70 mg/L	96-h	LC_{50}	10,500 (N/A)	Kulshrestha et al. 1986	1
Carp *Labeo rohita*	finger-ling	S,U	Formulation (30%)	60-70 mg/L	96-h	LC_{50}	10,200 (N/A)	Kulshrestha et al. 1986	1
Carp *Cirrhinus mrigala*	finger-ling	S,U	Formulation (30%)	60-70 mg/L	96-h	LC_{50}	10,100 (N/A)	Kulshrestha et al. 1986	1
Cladoceran *Daphnia magna*	<24-h	S,M	Formulation (10%)	223 mg/L	48-h	LC_{50}	830 (550-1,260)	Beusen and Neven 1989	1
Cladoceran *Daphnia magna*	<24-h	S,M	Formulation (10%)	223 mg/L	48-h	LC_{50}	830 (410-1,680)	Beusen and Neven 1989	1
Cladoceran *Daphnia magna*	<24-h	S,M	Formulation (10%)	223 mg/L	48-h	LC_{50}	830 (N/A)	Beusen and Neven 1989	1
Cladoceran *Daphnia magna*	<24-h	S,M	Formulation (10%)	223 mg/L	48-h	LC_{50}	1,260 (N/A)	Beusen and Neven 1989	1
Cladoceran *Daphnia magna*	<24-h	S,M	Formulation (10%)	223 mg/L	48-h	LC_{50}	1,600 (1,000-2,600)	Beusen and Neven 1989	1
Cyprinid *Saccobranchus fossilis*	N/A	S,U	Formulation (30%)	N/A	96-h	LC_{50}	4,570 (4,230-4,930)	Verma et al. 1982	1
Eastern oyster *Crassostrea virginica*	N/A	F,M	Technical (99%)	18-20 °/oo	96-h	EC_{50}	113,000 (78,000-124,000)	Graves and Swigert 1993b	5
Freshwater fish *Oreochromis mossambicus*	fry	S,U	Rogor-40	N/A	48-h	LC_{50}	28,510 (27,720-29,390)	Shafiei and Costa 1990	1,6
Freshwater fish *Oreochromis mossambicus*	finger-ling	S,U	Rogor-40	N/A	48-h	LC_{50}	31,260 (30,640-31,880)	Shafiei and Costa 1990	1,6

Table B-2.-cont- Values (µg/L) from unaccepted tests on the acute toxicity of dimethoate to aquatic animals.

Species	Life Stage	Method[b]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (95% C.L.[c])	Reference	Test Deficiencies[d]
Guppy *Poecilia reticulata*	N/A	S,M	Formulation (10%)	223 mg/L	96-h	LC_{50}	13,000 (10,900-15,400)	Beusen and Neven 1989	1
Guppy *Poecilia reticulata*	N/A	S,M	Formulation (10%)	223 mg/L	96-h	LC_{50}	10,400 (9,100-11,900)	Beusen and Neven 1989	1
Guppy *Poecilia reticulata*	N/A	S,M	Formulation (10%)	223 mg/L	96-h	LC_{50}	11,200 (N/A)	Beusen and Neven 1989	1
Mosquito *Culex pipiens*	4th instar	S,U	Formulation (5%)	N/A	48-h	LC_{100}	500 (N/A)	Rettich 1979	1
Mosquito *Anopheles quadrimaculatus*	4th instar	S,U	N/A	N/A	24-h	N/A	N/A	Schmidt et al. 1961	1,2
Mosquito *Aedes aegypti*	4th instar	S,U	N/A	N/A	24-h	N/A	N/A	Schmidt et al. 1961	1,2
Mosquito *Aedes taeniorhynchus*	4th instar	S,U	N/A	N/A	24-h	N/A	N/A	Schmidt et al. 1961	1,2
Rainbow trout *Oncorhynchus mykiss*	N/A	S,U	Technical (100%)	44 mg/L	96-h	LC_{50}	6,200 (41,300-9,300)	Mayer and Ellersieck 1965	2,5
Sheepshead minnow *Cyprinodon vareigatus*	juv.	S,M	Technical (99%)	21 °/∞	96-h	LC_{50}	>111,000	Graves and Swigert 1993b	5
Singhi *Heteropneustes fossilis*	N/A	S,U	Formulation (30%)	N/A	168-h	LC_{50}	45,710 (N/A)	Basak and Konar 1978	1,2
Tilapia *Tilapia mossambica*	N/A	S,U	Formulation (30%)	N/A	168-h	LC_{50}	23,770 (N/A)	Basak and Konar 1978	1,2
Zebrafish *Brachydanio rerio*	N/A	S,M	Formulation (10%)	223 mg/L	96-h	LC_{50}	6,800 (5,600-8,300)	Beusen and Neven 1989	1
Zebrafish *Brachydanio rerio*	N/A	S,M	Formulation (10%)	223 mg/L	96-h	LC_{50}	7,800 (6,900-8,900)	Beusen and Neven 1989	1
Zebrafish *Brachydanio rerio*	embryo	S,M	Technical (99%)	N/A	72-h	TL_m	259,000 (24,800-27,000)	Roales and Perlmutter 1974	6

APPENDIX C. Abstracts of accepted and unaccepted chronic toxicity tests reviewed for hazard assessment.

Accepted chronic toxicity tests - The following tests used accepted test methods.

Strawn (1994) - In 1994, a 96-d flow-through toxicity test was performed by ABC Laboratories in Columbia, Missouri on dimethoate (99%) with early life stage rainbow trout *Oncorhynchus mykiss*. ASTM (1992) and EPA (1982) test standards were used. Five concentrations were tested with four replicates per treatment, and water controls were used. Concentrations were measured weekly during the test. Water quality parameters during the test were: temperature of 8.6 to 10.8°C; pH of 7.85 to 8.16; dissolved oxygen of 7.9 to 10 mg/L; and hardness of 140 to 166 mg/L. Control survival was ≥95%. The 96-d NOEC, LOEC, and MATC, values based on growth, were 1,400 µg/L, 3,300 µg/L, and 2,100 µg/L, respectively.

Wuthrich (1990) - In 1990, a 21-d semi-static toxicity test was performed by RCC UMWELTCHEMIE AG in Itingen, Switzerland on dimethoate (99%) with ≤24 hr old cladoceran *Daphnia magna*. EPA (1981) guidelines were used. Six concentrations were tested in replicate and a water control was used. Concentrations were measured at 0, 2, 9, 12, 19, and 21 days. Water quality parameters were: temperature of 19.1 to 21.7°C; pH of 8.0 to 8.5; dissolved oxygen 7.5 to 9.5 mg/L; and hardness of 14.9 to 16.2 mg/L. Control survival was ≥95%. The EC_{50} value for *D.magna* based on immobilization of the parental generation, was 465 to 105 µg/L for days four and five; and for day six and after it was 88 to 82 µg/L. The EC_{50} for *D.magna*, based on reproduction rates, were between 40 to 100 µg/L. The estimated LD_{50} for *D.magna* was 465 µg/L. The Maximum Acceptable Toxicant Concentration (MATC) for *D.magna* was 63 µg/L.

Unaccepted chronic toxicity tests - The following tests did not use accepted test methods and/or produce acceptable results.

Gill et al. (1988) - In 1987, a 60-d static toxicity test was performed by Kumaun University, India on dimethoate (30%) with freshwater fish *Puntius conchonius* Ham. No commonly recognized testing standards were mentioned. Two concentrations were tested and a water control was used. Concentrations were not measured. Water quality parameters were: temperature of 13°C; pH of 7.4; dissolved oxygen of 8.06 mg/L; and hardness of 402.3 mg/L. Control survival was not given. Effects were not given. This test was not accepted because the percent active ingredient in the formulated product was below 90%, an inadequate number of concentrations were tested, and LOEC and NOEC values were not given.

Mohanty-Hejmadi and Dutta (1981) - In 1981, a 52-d static toxicity test was performed by Utkal University, India on Rogor (30% dimethoate) with Indian bullfrog tadpoles *Rana tigerina*. No commonly recognized test standards were mentioned. Twelve concentrations were tested and a water control was used. Water temperature was 30 to 38°C. No other water quality parameters were given. Control survival was 100%. No effects were given. This test was not accepted because the percent active ingredient in the formulated product was below 90% and LOEC and NOEC values were not given.

Pandey and Tomar (1985) - In 1984, a 21-d static toxicity test was performed by Vikram University, India on Rogor (percent active ingredient not given) on toad tadpoles *Bufo melanostictus*. No commonly recognized testing standards were mentioned. One concentration was tested and a water control was used. Concentrations were not measured. Water quality parameters during the test were: temperature of 28 to 32°C; pH of 8.2 to 8.5; and dissolved oxygen of 5.6 to 6.2 mg/L. Control survival was not given. Effects were not given. This test was not accepted because an inadequate number of concentrations were tested and LOEC and NOEC values were not given.

Ramana et al. (1992) - In 1989, a 21-d static toxicity test was performed by Jaydee Agrochemicals and Vikram University, India on Rogor (percent active ingredient not given) with mature guppies *Lebistes reticulatus*. No commonly recognized testing standards were mentioned. One concentration was tested and a water control was used. Concentrations were not measured. The temperature was 23°C. Other water quality parameters were not measured. Control survival was not given. Effects were not given. This test was not accepted because an inadequate number of concentrations were tested and LOEC and NOEC values were not given.

Table C-1. Values (µg/L) from accepted tests on the chronic toxicity of dimethoate to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values	Reference
Cladoceran *Daphnia magna*	≤24 hr	S,M	Technical (99%)	14.9-16.2 mg/L	21-d	MATC	63	Wuthrich 1990
Rainbow trout *Oncorhynchus mykiss*	early life stage	F,M	Technical (99%)	140-166 mg/L	96-d	NOEC LOEC MATC	1,400 3,300 2,100	Strawn 1994

[a] S = Static F = Flow through M = Measured concentrations

Table C-2. Values (µg/L) from unaccepted tests on the chronic toxicity of dimethoate to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values	Reference	Deficiencies[c]
Freshwater fish *Puntius conchonius*	N/A	S,U	Formulation (30%)	402.3 mg/L	60-d	N/A[b]	N/A[b]	Gill et al. 1988	1,2,3
Guppy *Lebistes reticulatus*	mature	S,U	Rogor (N/A)[b]	N/A[b]	21-d	N/A	N/A	Ramana et al. 1992	2,3
Indian bullfrog *Rana tigerina*	tadpole	S,U	Formulation (30%)	N/A	52-d	N/A	N/A	Mohanty-Hejmadi and Dutta 1981	1,3
Toad *Bufo melanostictus*	tadpole	S,U	Rogor (N/A)	N/A	21-d	N/A	N/A	Pandey and Tomar 1985	2,3

[a]S = Static U = Unmeasured concentrations

[b]N/A = Not available

[c]1 = Formulation too low in active ingredient
2 = Inadequate number of concentrations tested
3 = Pertinent values not determined

APPENDIX D. Abstracts of aquatic plant toxicity tests reviewed for hazard assessment.

Ibrahim (1983) - In 1983, 96-h static toxicity tests were performed by the Institute of Oceanography and Fisheries, Algal Assay Laboratory El-Zamalek, on dimethoate (percent active ingredient not given) with marine unicellular algae *Skeletonema costatum*, *Amphiprora paludosa*, and *Phaeodactylum tricornutum*. No commonly recognized test standards were mentioned. Five concentrations were tested and a control was used. Four replicates per concentration were tested. Water quality parameters during the test were: temperature of 25±1°C; and salinity of 30 °/$_{oo}$. Control survival was 100%. The EC_{50} values, based on dry weight, for *S. costatum*, *A. paludosa*, and *P. tricornutum* were 9,500, 12,500, and 6,850 µg/L, respectively.

Kobbia et al. (1991) - In 1991, 7-d static toxicity tests were performed by Cairo University, Egypt on dimethoate (commercial grade) with cyanobacteria *Nostoc muscorum* and *Anabaena oryzae*. No commonly recognized test standards were mentioned. Concentrations were not measured. Five concentrations were tested and a control was used. Water temperature was 28°C. No other water quality parameters were given. An LOEC and NOEC were not determined.

Mohapatra and Mohanty (1992a) - In 1992, 10-d static toxicity tests were performed by the Environmental Biology Laboratory, Department of Botany, Utkal University, on dimethoate (percent active ingredient not given) with algae *Chlorella vulgaris* and *Anabaena doliolum*. No commonly recognized testing standards were mentioned. Seven concentrations were tested and a control was used. Three replicates per concentration were tested. Water quality parameters during the test were: temperature of 27±2°C. Control survival was 100%. The LOEC and NOEC values were 10,000

and 1,000 µg/L, respectively, for *C. vulgaris* and 1,000 and <1,000 µg/L, respectively, for *A. doliolum*.

Mohapatra and Mohanty (1992b) - In 1992, 10-d static toxicity tests were performed by the Environmental Biology Laboratory, Department of Botany, Utkal University, on dimethoate (percent active ingredient not given) with cyanobacterium *Anabaena doliolum*. No commonly recognized testing standards were mentioned. One control was used. Exposure levels were measured during the test. The testing temperature was 27±2°C. Other water quality parameters were not given. Control survival was 100%. The EC_{50} for *A. doliolum* was 20,000 µg/L.

Perona, et al. (1991) - In 1991, toxicity tests were performed by the Biology Department, Faculty of Sciences, Autonoma University of Madrid, on technical grade dimethoate (percent active ingredient not given) with N_2-fixing cyanobacterium *Anabaena PCC 7119*. No commonly recognized testing standards were mentioned. Three concentrations were tested. Exposure levels were measured during the test. The testing temperature was 26°C. Other water quality parameters were not given. The LOEC value for *A. PCC 7119* was 100,000 µg/L.

Ramachandran et al. (1984) - In 1984, 6-h static toxicity tests were performed by the Centre of Advanced Study in Marine Biology, Annamalai University, on technical grade (96%) with marine macrophytes *Chaetomorpha linum, Enteromorpha intestinalis, Gracilaria verrucosa, Grateloupia doryphora, Halophila ovalis* and *Halodule uninervis*. No commonly recognized testing standards were mentioned. One concentration of dimethoate was tested. Three replicates were tested. Exposure levels were measured during the test. Water quality parameters during the test were: temperature of 30±2°; pH of 7.8; dissolved oxygen of 3.1±0.2 mg/L; and salinity of 31%. At 50 µg/L, the photosytnetic and respiration rates were 97% and 107% for *C. linum*, 92% and 76% for

E. instestinalis, 88% and 84% for *G. verrucosa*, 82% and 96% for *G. doryphora*, 86% and 103% for *H. ovalis*, and 76% and 102% for *H. uninervis*.

Sahu, et al. (1992) - In 1992, toxicity tests were performed by the Department of Botany, S.C.S. College, on dimethoate (30%) with blue-green algae *Chroococcus minutus, Gloeocapsa atrata, Aphanothece naegelei, Oscillatoria tenuis, Lyngbya major, Anabaenopsis circularis, Cylindrospermum muscicola, Nostoc punctiforme, Nostoc commune, Nostoc piscinale, Anabaena oryzae, Anabaena fertilissima, Aulosira fertilissima, Scytonema pascheri, Calothrix parietina, Hapalosiphon welwitschii* and *Westiellopsis prolifica*. No commonly recognized testing standards were mentioned. Five concentrations were tested. Ten replicates per concentration were tested. Exposure levels were measured during the test. Water quality parameters during the test were: temperature of 28±2°C; and pH of 7.8. The LOEC value was 100,000 µg/L.

Table D-1. Values (µg/L) from tests on the toxicity of dimethoate to aquatic plants.

Species	Formulation	Test Length	Endpoint/ Effect	Concentration (µg/L)	Reference
Cyanobacteria *Nostoc muscorum*	Commercial	7-d	N/A[a]	N/A[a]	Kobbia et al. 1991
Cyanobacteria *Anabaena oryzae*	Commercial	7-d	N/A	N/A	Kobbia et al. 1991
Cyanobacteria *Anabaena doliolum*	N/A[a]	10-d	LOEC NOEC	1,000 <1,000	Mohaptra and Mohanty 1992a
Cyanobacteria *Anabaena doliolum*	N/A	10-d	EC_{50}/ growth inhibition	20,000	Mohaptra and Mohanty 1992b
Cyanobacteria *Anabaena* PCC7119	Technical	96-h	LOEC/ growth inhibition	100,000	Perona et al. 1991
Cyanobacteria (mixture)	30% E.C.	N/A[a]	LOEC/ growth inhibition	100,000	Sahu et al. 1992
Green algae *Chlorella vulgaris*	N/A	10-d	LOEC NOEC	10,000 1,000	Mohaptra and Mohanty 1992a
Marine algae *Amphiprora paludosa*	N/A	96-h	EC_{50}/ dry weight	12,500	Ibrahim 1983
Marine algae *Chaetomorpha linum*	Technical (96%)	6-h	N/A	N/A	Ramachandran et al. 1984
Marine algae *Enteromorpha intestinalis*	Technical (96%)	6-h	N/A	N/A	Ramachandran et al. 1984
Marine algae *Gracilaria verrucosa*	Technical (96%)	6-h	N/A	N/A	Ramachandran et al. 1984
Marine algae *Gratiloupia doryphora*	Technical (96%)	6-h	N/A	N/A	Ramachandran et al. 1984
Marine algae *Halophila ovalis*	Technical (96%)	6-h	N/A	N/A	Ramachandran et al. 1984
Marine algae *Halodule uninervis*	Technical (96%)	6-h	N/A	N/A	Ramachandran et al. 1984

Table D-1.-cont- Values (µg/L) from tests on the toxicity of dimethoate to aquatic plants.

Species	Formulation	Test Length	Endpoint/ Effect	Concentration (µg/L)	Reference
Marine algae *Phaeodactylum tricornutum*	N/A	96-h	EC_{50}/ dry weight	6,850	Ibrahim 1983
Marine algae *Skeletonema costatum*	N/A	96-h	EC_{50}/ dry weight	9,500	Ibrahim 1983

[a] N/A = Not available